Published in final edited form as:
Ann Epidemiol. 2010 May ; 20(5): 323–331. doi:10.1016/j.annepidem.2010.02.007.

Associations of Job Strain and Occupation with Subclinical Atherosclerosis: the CARDIA Study

Kurt J. Greenlund, PhD, **Catarina I. Kiefe, PhD MD**, **Wayne H. Giles, MD, MPH**, and **Kiang Liu, PhD**
Division of Adult and Community Health, Centers for Disease Control and Prevention, Atlanta Georgia (KJG, WHG), Division of Preventive Medicine, University of Alabama School of Medicine, Birmingham Alabama (CIK), and Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago Illinois (KL)

Abstract

Purpose—Although occupational factors have been associated with symptomatic ischemic heart disease, associations between job strain (low decision latitude and high psychological demands) and risk for subclinical atherosclerosis measured by coronary artery calcium (CAC) has not been assessed.

Methods—CAC was measured in 3,695 participants in the Coronary Artery Risk Development in Young Adults (CARDIA) study in 2000-01 and 2005-06. Job characteristics measured by the demand-control model (psychological demands and decision latitude) were assessed in 1987-88 and in 1995-96. Associations between non-zero CAC and prior job characteristics and occupation were assessed, adjusting for potential covariates.

Results—Low decision latitude, high psychological demands, and job strain at either earlier exam were not associated with a positive CAC, nor were changes in the status of these job characteristics between 1987/1988 and 1995/1996. However, participants whose jobs were classified as managerial or professional in 1995/1996 were less likely to have a positive CAC than those in laborer occupations.

Conclusions—Job strain measured at two earlier time points was not related to the presence of CAC at follow-up 5 to 18 years later. The association between earlier occupation and CAC may reflect socioeconomic differences or other occupational, industrial, or labor market characteristics.

MESH headings

coronary atherosclerosis; occupation; psychological stress; socioeconomic factors

Occupation and work characteristics have been investigated with regard to coronary heart disease (CHD). Occupation has traditionally been used as an indicator of socioeconomic status, and work characteristics such as high work demands and low control over job duties and low use of skills have been investigated (1). Several studies have observed associations between

Correspondence to: Kurt J. Greenlund, PhD, Centers for Disease Control and Prevention, 4770 Buford Highway NE, Mailstop K-45, Atlanta, Georgia 30341, Phone 770-488-2572, FAX 770-488-5964, keg9@cdc.gov.

Disclosures: None

job strain (defined as low decision latitude and high psychological demands) and CHD risk (2-7), although others observed no significant association (8-11). In the Coronary Artery Risk Development in Young Adults (CARDIA) study, job strain had little or no cross-sectional association with cardiovascular risk factors among young adults (11) but was significantly associated with incident hypertension over 8 years among the full cohort and among whites specifically (12).

Measures of subclinical atherosclerosis have drawn attention in epidemiologic studies as advantageous over self reports and clinical identification of disease status. Studies examining associations between job stress (variously defined) and subclinical disease measures such as carotid intima-media thickness or coronary stenosis have produced mixed results (7,8,13-17) but have shown associations even in young adults (7,13). Likewise, occupation has been related to CHD and subclinical atherosclerosis (18-20). Diez-Roux (20), for example, observed greater CHD prevalence and increased carotid wall thickness in lower occupational categories.

Coronary artery calcium (CAC) has attracted attention as an indicator of subclinical coronary artery disease (21-24). This measure of the calcified component of coronary artery plaque is strongly associated with the extent of atherosclerosis and with risk for cardiac events (21,22, 24). Associations of CAC with early adult levels of modifiable risk factors have been noted (25). Loria and colleagues (25) observed that baseline risk-factor levels were equally or more informative for predicting the odds of a positive CAC in middle age than were subsequent risk-factor levels, and baseline levels were equally predictive of future CAC risk as changes in risk-factor levels.

No studies examining associations of job strain or occupation with CAC were found in the literature. Given observed associations of young adult risk factors with CAC levels later in life (25) and of job stress with other measures of subclinical atherosclerosis in young adults (7, 13), we examined associations of occupation and job strain, as well as changes in job strain, in young adulthood with coronary artery calcium in the CARDIA study. We hypothesized that job strain would be positively associated with the presence of CAC.

Methods

CARDIA is a multicenter, longitudinal study of the development of coronary artery disease risk beginning in young adulthood (26). The cohort consists of 5115 black and white adults aged 18 to 30 years at baseline (1985/1986) recruited from 4 metropolitan areas (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). Within each center, the sample comprised approximately equal numbers of participants by sex, race (black or white), age (18–24 years or 25–30 years), and education (≤ high school graduate or >high school graduate). Participants were re-examined 6 times over approximately 20 years. Participants were more likely to be white, male, older, and with more education when compared to those eligible but who did not participate in the study (26). All examinations were approved by the institutional review boards of participating institutions, and written informed consent was obtained from study participants. Analyses were approved by the CARDIA Steering Committee.

Our analyses used data from the CARDIA year 2 (1987/1988), year 10 (1995/1996), year 15 (2000/2001) and year 20 (2005/2006) examinations. Occupation was collected at each examination and coded to U.S. census categories. For these analyses only occupation at years 2 and 10 were assessed; to coincide with job strain measures. Job characteristics were measured at years 2 and 10 using the 14-item Job Content questionnaire (27). Participants' agreement with each item was measured on a scale of 1 to 4, indicating strong disagreement to strong agreement. A "psychological job demands" score is based responses to 5 items about working fast, working hard, having excessive work, not having enough time to do work, and facing conflicting demands at work. “Decision latitude” is based on responses to 9 items related to learning new things, creativity, level of skill, task variety, special skills, repetition, ability to make personal decisions about how to work, having say in one’s job, and freedom to decide how to do one’s job. The scales developed by Karasek weight some items resulting in a range from 12 to 48. Following Markovitz and colleagues (12), we used sex-race median cut points to define high or low psychological demands and decision latitude. Job strain, a derived dichotomous variable, was defined as having a job with high psychological demands and low decision latitude. We also examined job strain as a continuous variable, defined as the ratio of the demands score divided by the decision latitude score; a higher ratio indicates more job strain.

Coronary artery calcium in the main coronary arteries (left main, left circumflex, left anterior descending and right) was measured at year 15 (2000/2001) and at year 20 (2005/2006). Two computed tomography (CT) scans were obtained for each participant by using electron beam CT (Imatron C-150, GE Medical Systems, Milwaukee, Wisconsin [Chicago and Oakland centers]) or multidetector CT scanners (either GE Lightspeed, GE Medical Systems [Birmingham center] or Volume Zoom, Siemens, Erlangen, Germany [Minneapolis center]). For each scan, 40 consecutive images from the root of the aorta to the apex of the heart were obtained. Participants were ineligible for CT scanning if they were pregnant (18 at year 15, 7 at year 20) or if their body weight was above scanner limits (44 at year 15, 37 at year 20). A trained technician examined each image and identified potential foci of CAC using specially developed image-processing software. An expert investigator reviewed and adjudicated all discordant scan pairs. Quality control analyses suggested high between- and within-reader agreement and acceptable paired scan agreement, with only 4% discordant pair scans (28). We considered coronary calcium to be present in participants with an Agatston score >0 at either exam. The presence/absence of CAC has been previously used in CARDIA (25,29) because of the relatively young age and small numbers when examining the distribution of CAC.

Other variables considered for analyses were participants’ age, education level, examination center, and risk factors which consisted of smoking status, body mass index, systolic and diastolic blood pressure, fasting plasma cholesterol concentrations (total, low-density lipoprotein, and high-density lipoprotein), alcohol use, and physical activity level.

We used chi-square tests to assess unadjusted associations between participants’ job characteristics and the presence of CAC. Multiple logistic regression models were used to calculate adjusted odds ratios (AORs) and 95% confidence intervals (CIs). For any job characteristics significantly associated with the presence of CAC in unadjusted analyses, we then adjusted for the previously described risk factors to assess whether the association was independent of these risk factors. Associations between the presence of CAC and job characteristics were assessed separately for job characteristics at year 2 and at year 10. In addition, we examined prevalence of CAC with changes in high/low decision latitude, demands, and job strain between year 2 and year 10 among those with job characteristics measured at both exams. Analyses were conducted with SAS statistical software version 9.1 (SAS Institute Inc, Cary, NC), with $P<0.05$ considered statistically significant.

Results

About 90% of the original 5,115 subjects participated in the 1987/1988 examination; of these, 4,211 had job content scores. About 77% participated in the 1995/1996 examination; 3,865 had job content scores. About 74% participated in the 2000/2001 examination, with 3,042 having CAC measures. About 72% participated in the 2005-2006 examination, with 3,137 having CAC measures. Of 3,695 participants who had CAC assessed at either the CARDIA year 15 or year 20 exam, 88% had job strain scores from year 2 (1987/1988), and 89% had job strain scores from year 10 (1995/1996) (Figure 1). Conversely, 77% of those with job strain scores at year 2 and 85% of those with job strain scores at year 10 had CAC measured at either year 15 or year 20.

About equal percentages of those with and without CAC measures reported being in any combination of low/high demand and low/high latitude jobs at either earlier exam. For example, the percentages with low latitude/low demands, high latitude/low demands, low latitude/high demands, and high latitude/high demands at the year 10 exam with versus without a scan were 31% vs 33%, 24% vs 23%, 21% vs 19% and 24% vs 24% respectively. Likewise, the percentage of participants with a CAC score differed little by whether their job characteristics were measured at year 2 or year 10.

About 23% of participants in the year 2 exam and 21% of those at the year 10 exam had high-strain jobs (Table 1). Black men (P=0.02) and black women (P=0.03) were somewhat more likely to report having high-strain jobs than white men and women, respectively. White women had the highest percentage of jobs with high decision latitude and high psychological demands. As would be expected, participants with managerial occupations and those with higher education were more likely to report high job decision latitude at both year 2 and year 10 than were laborers and those with less than a high school education, respectively (P=0.0001 for occupation overall and education overall for both exams) (Figure 2a). High psychological job demands were reported most frequently by respondents in managerial occupations (P= 0.002 at year 2 and P= 0.0001 at year 10 for overall association between high psychological demands and occupational group) (Figure 2b). Job strain was greatest among the operators/ fabricators/ laborers occupational group (P =0.0001 for overall association for exams) (Figure 2c).

About 17.7% of the participants had a positive CAC for the combined year 15 (prevalence=9.6%) and year 20 (prevalence=18.5%) examinations. Previous CARDIA analyses observed that male sex and older age were positively associated with CAC (25,29). In unadjusted analyses, job characteristics based on high/low psychological demands and decision latitude at either year 2 or year 10 was not associated with the presence of CAC (Table 2). Among women at the year 2 exam, there was an apparent race difference in the direction of association of decision latitude with prevalence of CAC, with white women having a higher prevalence of CAC with higher decision latitude and black women having a lower prevalence with higher latitude, although differences within race-sex groups were not significant. Among the total sample, participants in blue collar jobs (precision/craft/repair and operators/ fabricators/laborers) at year 2 and year 10 tended to show a higher prevalence of a positive CAC than workers in other occupational categories (P =0.0001 for overall association).

When examined as either continuous or as categorical variables in multivariate models, decision latitude, psychological demands, and job strain were not associated with the probability of a positive CAC (Table 3). However, occupational category was related to a positive CAC. Those in managerial/professional or technical/sales/support occupational categories at either year 2 or year 10 had a lower likelihood of a positive CAC than were those in the operators/fabricators/laborers category. After adjusting for systolic and diastolic blood pressure, body mass index, physical activity, cholesterol, smoking status, and alcohol use status, associations between occupational category and probability of subsequent CAC risk remained significant for year 10 occupation but were attenuated for year 2 occupation (data not shown).

Among 2943 participants with a CAC measurement and with job characteristics measured at both years 2 and 10, there were no substantial differences in the prevalence of CAC based on changes in decision latitude, psychological demands or job strain. For example, the unadjusted prevalence of CAC was 13.0% among those with job strain at both years 2 and 10 and 18.2% among those with no job strain at both years; differences were not statistically significant in multivariable adjusted models (Table 4).

We tested the interaction of race and decision latitude with the probability of CAC among women at year 2 suggested in the crude analyses (Table 2). With analyses restricted to women, we entered an interaction term of race X decision latitude (as a continuous variable) into the models along with the lower-order terms and other covariates. The interaction term was of borderline significance (P=0.053), with an increase in decision latitude among black women being associated with a lower likelihood of CAC compared to white women.

Discussion

To our knowledge this is the first study to report on associations of job strain and occupation in young adulthood with subclinical atherosclerosis measured by coronary artery calcium. We observed no association between job strain measured at two time points in young adulthood and subsequent CAC, at least 5 and up to 18 years later. Analyses stratified by race-sex groups suggested potential racial differences in the patterns of associations between subclinical atherosclerosis and job strain, but our study had limited power to examine these associations in detail. By occupation, the prevalence of CAC tended to be highest among people who had had blue collar jobs, even after adjusting for sociodemographic and cardiovascular risk factors.

Results from studies of the relationship between job strain and CHD have been mixed. Community-based U.S. studies did not show direct associations between job strain and CHD mortality (9,10,30-33), whereas direct associations were observed in studies from other countries (6,34-36). A review of longitudinal studies suggested only modest support for the job strain—CHD risk hypothesis (37). A meta-analysis of 14 prospective studies suggested that CHD risk greater among workers with high versus low job strain after adjustments for age and sex, but was attenuated after further adjustments for other risk factors and potential mediators (38). Other studies of associations between job stress and risk factors produced similarly mixed results (11,12,39). Differences in study results could reflect differences in how job stress or cardiovascular variables were assessed, differences in how respondents interpreted job content questions, cultural differences in how different study populations respond to job stressors, or other factors. Other job characteristics (e.g., passive jobs) may also be associated with cardiovascular risk (40). Although our sample sizes are small, a possible interaction of race with decision latitude with the probability of CAC among women deserves further attention, as others observed (albeit mixed) associations of high latitude/ high demand jobs with cardiovascular risk among women (9,10).

Several studies have observed associations of job strain with increased carotid intima media thickness (IMT) and other measures of subclinical cardiovascular disease. Muntaner (15) found job characteristics to be associated with carotid IMT in the Atherosclerosis Risk in Communities (ARIC) study but did not directly assess the job strain hypothesis. Rosvall (8) found job strain to be associated with increased carotid IMT and plaque in women but not in men, while the opposite was also observed (7,13). Among Japanese male factory workers, job strain was associated with hyperintense spots and elevated pulse-wave velocity (41). Greater arterial stiffness was observed among female but not male Japanese government workers with job strain (42). Nomura (43), however, found a negative association between job strain and arterial stiffness. Nordstrom (13) observed a greater prevalence of carotid lesions and increased carotid intima media thickness among men in the highest compared to lowest quintile of job stress but not among women. Further studies may help to elucidate these disparate findings and whether job strain might be associated with development of subclinical atherosclerosis at different sites.

Participants in white collar jobs as young adults had a lower probability of CAC than those in blue collar jobs, even after adjusting for conventional cardiovascular risk factors and education level. Further investigation into the relationship between occupational characteristics and risk for subclinical disease may include the extent to which occupation reflects socioeconomic status and the extent to which the structure of work differs by occupational category. Occupation, along with income and education, has been used as an indicator of socioeconomic status (44), although the shortcomings of any of these indicators for adequately reflecting socioeconomic status have been recognized (45). Whether occupation specific factors such as job loss or changes in job content due to mechanization or globalization may be related to job strain or disease development among workers in particular occupations or industries might be further investigated.

Strengths of our study include use of carefully measured data collected at multiple times over nearly 20 years. Our study included job characteristics measured at two time points in young adulthood. Use of single-time exposure measures may underestimate the extent to which long-term job strain is a CHD disease risk factor (46,47). However, the CARDIA cohort was selected from only 4 U.S. communities and may not reflect the full spectrum of occupations and levels of job stress of U.S. workers. Although we did not detect differential dropout by job characteristics overall, it is possible that those with higher job strain chose not to participate in the CARDIA study in the first place. For example, African Americans and those with lower education were less likely to participate. However, our observed associations of occupation with job strain and with CAC were in expected directions, in accordance with well-known associations of socioeconomic status with cardiovascular disease, and lend support to our observations of no association of job strain with CAC. In addition, because we did not have job strain data for any period after 1995/1996, we were unable to assess associations between more recent measures of job strain and CAC. Such information would be particularly relevant in analyses of risk among U.S. workers given that they change jobs quite often: only about 50% of CARDIA participants were in the same occupational category in 1995/1996 that they were in 1987/1988. Additionally, the CARDIA cohort was not large enough to examine whether job strain within particular occupational categories may be related to subclinical disease. Finally, due to the still relatively young age, we only assessed the presence or absence of CAC, not the extent of plaque present in individuals.

Despite these limitations, our results suggest that job strain in early young adult life was not associated with subsequent subclinical disease as indicated by a positive CAC, whereas occupational category was associated with such risk. The extent to which the association of occupation with the presence of CAC reflects socioeconomic factors or job-related factors other than job strain deserves further investigation.

Acknowledgments

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

This work was partially supported by the following National Institutes of Health, National Heart, Lung and Blood Institute contracts: University of Alabama at Birmingham, Coordinating Center, N01-HC-95095; University of Alabama at Birmingham, Field Center, N01-HC-48047; University of Minnesota, Field Center and Diet Reading Center (Year 20 Exam), N01-HC-48048; Northwestern University, Field Center, N01-HC-48049; Kaiser Foundation Research Institute, N01-HC-48050; University of California, Irvine, Echocardiography Reading Center (Year 5 & 10), N01-HC-45134; Harbor-UCLA Research Education Institute, Computed Tomography Reading Center (Year 15 Exam), N01-HC-05187; Wake Forest University (Year 20 Exam), N01-HC-45205; New England Medical Center (Year 20 Exam).

References

1. Belkic KL, Landsbergis PA, Schnall PL, Baker D. Is job strain a major source of cardiovascular disease risk? Scand J Work, Env and Health 2004;30(2):85–128. [PubMed: 15127782]
2. Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. Am J Public Health 1981;71(7):694–705. [PubMed: 7246835]
3. Steptoe A, Fieldman G, Evans O, Perry L. Control over work pace, job strain, and cardiovascular responses in middle-aged men. J Hypertens 1993;11(7):751–759. [PubMed: 8228195]
4. Schnall PL, Landsbergis PA, Baker D. Job strain and cardiovascular disease. Ann Rev Public Health 1994;15:381–411. [PubMed: 8054091]
5. Bosma H, Peter R, Siegrist J, Marmot M. Two alternative job stress models and the risk of coronary heart disease. Am J Public Health 1998;88(1):68–74. [PubMed: 9584036]
6. Kivimäki M, Leino-Arjas P, Luukkonen R, Riihimaki H, Vattern J, Kirjonen J. Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. BMJ 2002;325(7369): 857–860. [PubMed: 12386034]
7. Hintsanen M, Kivimäki M, Elovainio M, Pulka-Råback, Keskivaara P, Juonala M, Raitakari OT, Keltikangas-Järvinen L. Job strain and early atherosclerosis: the Cardiovascular Risk in Young Finns Study. Psychosom Med 2005;67(5):740–747. [PubMed: 16204432]
8. Rosvall M, Ostergren PO, Hedblad B, Isacsson SO, Janzon L, Berglund G. Work-related psychosocial factors and carotid atherosclerosis. Int J Epidemiol 2002;31(6):1169–1178. [PubMed: 12540718]
9. Eaker ED, Sullivan LM, Kelly-Hayes M, D'Agostino RB Sr, Benjamin EJ. Does job strain increase the risk for coronary heart disease or death in men and women? The Framingham Offspring Study. Am J Epidemiol 2004;159(10):950–958. [PubMed: 15128607]
10. Lee S, Colditz G, Berkman L, Kawachi I. A prospective study of job strain and coronary heart disease in US women. Int J Epidemiol 2002;31(6):1147–1153. [PubMed: 12540714]
11. Greenlund KJ, Liu K, Knox SS, McCreath H, Dyer AR, Gardin JM. Psychosocial work characteristics and cardiovascular disease risk factors in young adults: The CARDIA Study. Soc Sci Med 1995;41 (5):717–723. [PubMed: 7502103]
12. Markovitz J, Matthews K, Whooley M, Lewis CE, Greenlund K. Increases in job strain are associated with incident hypertension in the CARDIA Study. Ann Behav Med 2004;28(1):4–9. [PubMed: 15249254]
13. Nordstrom CK, Dwyer KM, Merz CNB, Shircore A, Dwyer JH. Work related stress and early atherosclerosis. Epidemiology 2001;12(2):180–185. [PubMed: 11246578]
14. Yoshimasu K, Liu Y, Kodama H, Sasazuki S, Washio M, Tanaka K, Tokunaga S, Kono S, Arai H, Koyanagi S, Hiyamuta K, Doi Y, Kawano T, Nakagaki O, Takada K, Nii T, Shirai K, Ideishi M, Arakawa K, Mohri M, Takeshita A. Job strain, type-A behavior pattern, and the prevalence of coronary atherosclerosis in Japanese working men. J Psychomatic Res 2000;49(1):77–83.
15. Muntaner C, Nieto FJ, Cooper L, Meyer J, Szklo M, Tyroler HA. Work organization and atherosclerosis: findings from the ARIC Study. Am J Prev Med 1998;14(1):9–18. [PubMed: 9476831]
16. Everson SA, Lynch JW, Chesney MA, Kaplan GA, Goldberg DE, Shade SB, Cohen RD, Salonen R, Salonen JT. Interaction of workplace demands and cardiovascular reactivity in progression of carotid atherosclerosis: population-based study. BMJ 1997;314(7080):553–558. [PubMed: 9055713]
17. Lynch J, Krause N, Kaplan GA, Salonen R, Salonen JT. Workplace demands, economic reward, and progression of carotid atherosclerosis. Circulation 1997;96(8):302–307. [PubMed: 9236449]
18. McFadden E, Luben R, Wareham N, Bingham S, Khaw K-T. Occupational social class, risk factors and cardiovascular disease incidence in men and women: a prospective study in the European Prospective Investigation of Cancer and Nutrition in Norfolk (EPIC-Norfolk) cohort. Eur J Epidemiol 2008;23(8):449–458. [PubMed: 18509727]
19. Rosvall M, Östergren P-O, Hedblad B, Isacsson S-O, Janzon L, Berglund G. Socioeconomic differences in the progression of carotid atherosclerosis in middle-aged men and women with subclinical atherosclerosis in Sweden. Soc Sci Med 2006;62(7):1785–1798. [PubMed: 16181715]

20. Diez-Roux AV, Nieto FJ, Tyroler HA, Crum LD, Szklo M. Social inequalities and atherosclerosis: the Atherosclerosis Risk in Communities study. Am J Epidemiol 1995;141(10):960–972. [PubMed: 7741126]

21. Bild DE, Folsom AR, Lowe LP, Sidney S, Kiefe C, Westfall AO, Zheng ZJ, Rumberger J. Prevalence and correlates of coronary calcification in black and white young adults: the Coronary Artery Risk Development in Young Adults (CARDIA) study. Arterioscler Thromb Vasc Biol 2001;21(5):852–857. [PubMed: 11348886]

22. Bild DE, Detrano R, Peterson D, Guerci A, Liu K, Shahar E, Ouyang P, Jackson S, Saad MF. Ethnic differences in coronary calcification: the Multi-Ethnic Study of Atherosclerosis (MESA). Circulation 2005;111(10):1313–1320. [PubMed: 15769774]

23. Kronmal RA, McClelland RL, Detrano R, Shea S, Lima JA, Cushman M, Bild DE, Burke GL. Risk factors for the progression of coronary artery calcification in asymptomatic subjects: results from the Multi-Ethnic Study of Atherosclerosis (MESA). Circulation 2007;115(21):2722–2730. [PubMed: 17502571]

24. Detrano R, Guerci AD, Carr JJ, Bild DE, Burke G, Folsom AR, Liu K, Shea S, Szklo M, Bluemke DA, O'Leary DH, Tracy R, Watson K, Wong ND, Kronmal RA. Coronary calcium as a predictor of coronary events in four racial or ethnic groups. N Engl J Med 2008;358(13):1336–1345. [PubMed: 18367736]

25. Loria CM, Liu K, Lewis CE, Hulley SB, Sidney S, Schreiner PJ, Williams OD, Bild DE, Detrano R. Early adult risk factor levels and subsequent coronary artery calcification: the CARDIA Study. J Am Coll Cardiol 2007;49(20):2013–2020. [PubMed: 17512357]

26. Friedman GD, Cutter GR, Donahue RP, Hughes GH, Hulley SB, Jacobs DR Jr, Liu K, Savage PJ. CARDIA: study design, recruitment, and some characteristics of the examined subjects. J Clin Epidemiol 1988;41(11):1105–1116. [PubMed: 3204420]

27. Karasek, RA. Job Content Instrument Questionnaire and User's Guide, Version I. Department of Industrial and Systems Engineering, University of Southern California; Los Angeles: Mar. 1985

28. Carr JJ, Nelson JC, Wong ND, McNitt-Gray M, Arad Y, Jacobs DR Jr, Sidney S, Bild DE, Williams OD, Detrano RC. Calcified coronary artery plaque measurement with cardiac CT in population-based studies: standardized protocol of Multi-Ethnic Study of Atherosclerosis (MESA) and Coronary Artery Risk Development in Young Adults (CARDIA) study. Radiology 2005;234:35–43. [PubMed: 15618373]

29. Yan LL, Liu K, Daviglus ML, Colangelo LA, Kiefe CI, Sidney S, Matthews KA, Greenland P. Education, 15-year risk-factor progression, and coronary artery calcium in young adulthood and early middle age: the Coronary Artery Risk Development in Young Adults study. JAMA 2006;295(15): 1793–1800. [PubMed: 16622141]

30. Hlatky MA, Lam LC, Lee KL, Clapp-Channing NE, Williams RB, Pryor DB, Califf RM, Mark DB. Job strain and the prevalence and outcome of coronary artery disease. Circulation 1995;92(3):327–333. [PubMed: 7634445]

31. Alterman T, Shekelle RB, Vernon SW, Burau KD. Decision latitude, psychologic demand, job strain, and coronary heart disease in the Western Electric Study. Am J Epidemiol 1994;139(6):620–627. [PubMed: 8172173]

32. Amick BC III, McDonough P, Chang H, Rogers WH, Pieper CF, Duncan G. Relationship between all-cause mortality and cumulative working life course psychosocial and physical exposures in the United States labor market from 1968 to 1992. Psychosom Med 2002;64(3):370–381. [PubMed: 12021412]

33. Reed DM, LaCroix AZ, Karasek RA, Miller D, MacLean CA. Occupational strain and the incidence of coronary heart disease. Am J Epidemiol 1989;129(3):495–502. [PubMed: 2916542]

34. Aboa-Éboul C, Brisson C, Maunsell E, Mâsse B, Bourbonnais R, Vézina M, Milot A, Théroux P, Dagenais GR. Job strain and risk of acute recurrent coronary heart disease events. JAMA 2007;298 (14):1652–1660. [PubMed: 17925517]

35. Kuper H, Marmot MJ. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II Study. J Epidemiol Community Health 2003;57(2):147–153. [PubMed: 12540692]

36. Netterstrøm B, Kristensen TS, Sjøl A. Psychological job demands increase the risk of ischaemic heart disease: a 14-year cohort study of employed Danish men. Eur J Cardiovasc Prev Rehabil 2006;13 (3):414–420. [PubMed: 16926672]
37. De Lange AH, Taris TW, Houtman IL, Bongers PM. "The very best of the millennium": longitudinal research and the demand-control-(support) model. J Occup Health Psychol 2003;8(5):282–305. [PubMed: 14570524]
38. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work stress in the etiology of coronary heart disease—a meta-analysis. Scand J Work Environ Health 2006;32(6):431–442. [PubMed: 17173200]
39. Siegrist J, Rödel A. Work stress and health risk behavior. Scand J Work Environ Health 2006;(6): 473–481. [PubMed: 17173203]
40. Steenland K, Johnson J, Nowlin S. A follow-up study of job strain and heart disease among males in the NHANES1 population. Am J Ind Med 2007;31(2):256–259. [PubMed: 9028443]
41. Michikawa T, Nishiwaki Y, Nomiyama T, Uemura T, O'Uchi T, Sakurai H, Omae K, Takebayashi T. Job strain and arteriosclerosis in three different types of arteries among male Japanese factory workers. Scand J Work Environ Health 2008;34(1):48–54. [PubMed: 18427698]
42. Utsugi M, Saijo Y, Yoshioka E, Sato T, Horikawa N, Gong Y, Kishi R. Relationship between two alternative occupational stress models and arterial stiffness: a cross-sectional study among Japanese workers. Int Arch Occup Environ Health 2009;82(2):175–183. [PubMed: 18365237]
43. Nomura K, Nakao M, Karita K, Nishikitani M, Yano E. Association between work-related psychological stress and arterial stiffness measured by brachial-ankle pulse-wave velocity in young Japanese males from an information service company. Scand J Work Environ Health 2005;31(5): 352–359. [PubMed: 16273961]
44. Berkman, LF.; Macintyre, S. The measurement of social class in health studies: old measures and new formulations. In: Kogevinas, M.; Pearce, N.; Susser, M.; Boffetta, P., editors. Social Inequalities and Cancer. Lyon, France: International Agency for Research on Cancer; 1997. p. 51-64.IARC Scientific Publications No. 138
45. Braveman PA, Cubbin C, Egerter S, Chideya S, Marchi KS, Metzler M, Posner S. Socioeconomic status in health research: one size does not fit all. JAMA 2005;294(22):2879–2888. [PubMed: 16352796]
46. Kivimäki M, Head J, Ferrie JE, Brunner E, Marmot MG, Vahtera J, Shipley MJ. Why is evidence on job strain and coronary heart disease mixed? An illustration of measurement challenges in the Whitehall II Study. Psychosom Med 2006;68(3):398–401. [PubMed: 16738070]
47. Smith P, Beaton D. Measuring change in psychosocial working conditions: methodological issues to consider when data are collected at baseline and one follow-up time point. Occup Environ Med 2008;65(4):288–296. [PubMed: 18349161]

Abbreviations

AOR	adjusted odds ratio
CAC	coronary artery calcium
CARDIA	Coronary Artery Risk Development in Young Adults
CHD	coronary heart disease
CI	confidence interval
CT	computed tomography

NIH-PA Author Manuscript

NIH-PA Author Manuscript

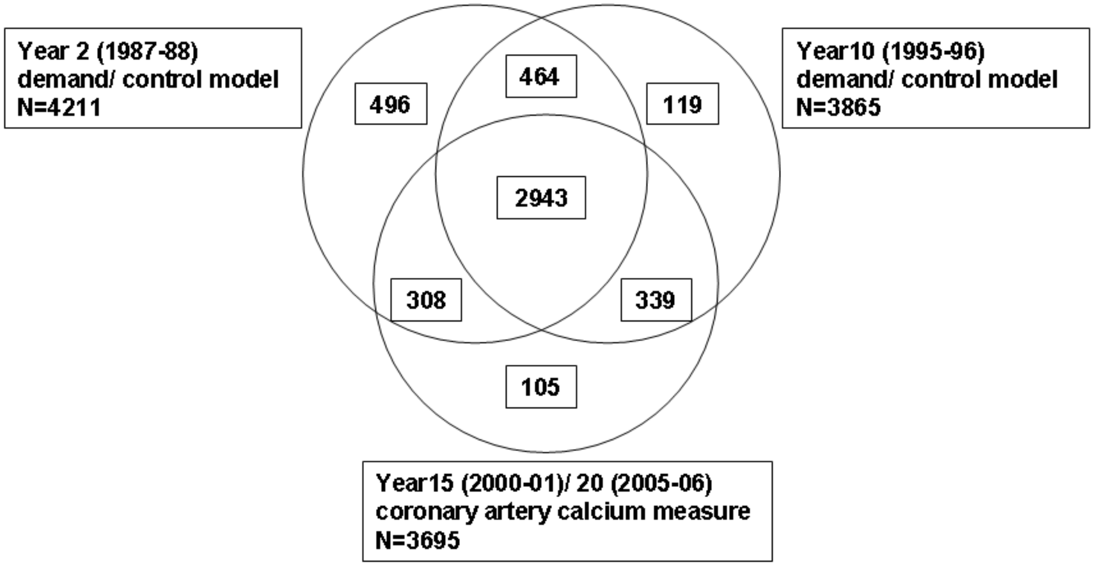

Figure 1.
Sample Sizes for CARDIA Participants (n=5115 at baseline in 1985/1986) With Job Content and Coronary Artery Calcium Measures.

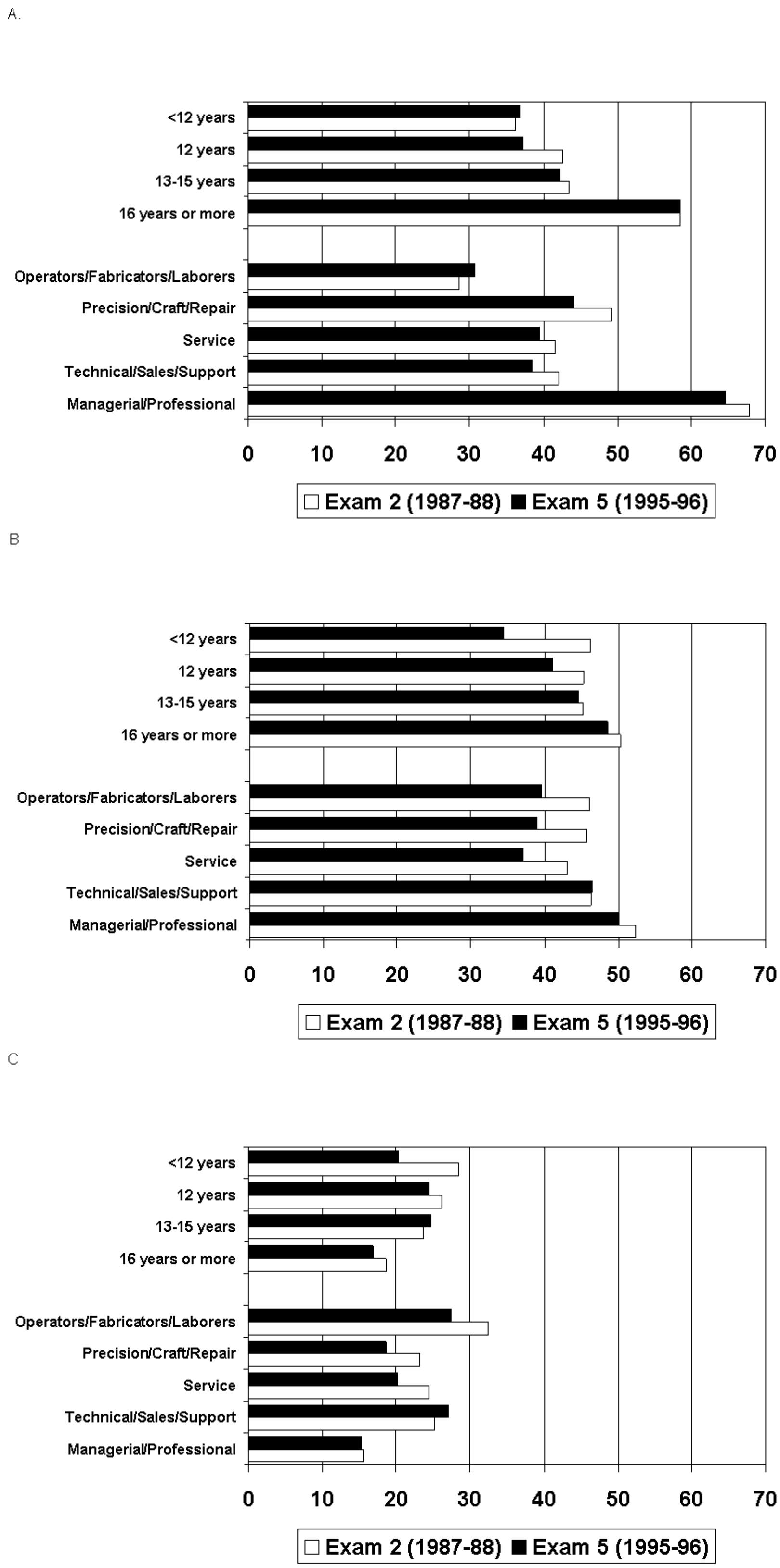

Figure 2.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Percentage of CARDIA Participants With Jobs Having (A) High Decision Latitude, (B) High Psychological Demands, and (C) High Strain (Low Decision Latitude, High Demands), by Education Level and Occupation.

Table 1

Distribution of Selected Characteristics of CARDIA Study Participants, by Age and Sex, 1987/1988 and 1995/1996

Characteristics	Total	White men	Black men	White women	Black women
Year 2 (1987-88)					
N	4622	1102	988	1234	1298
Mean age, y (Standard error)	27.0 (0.05)	27.5 (0.10)	26.3 (0.12)	27.5 (0.10)	26.5 (0.11)
Job characteristics (N=4211)					
Median decision latitude score	36	38	34	36	34
Median psychological demands score	32	32	30	32	31
Low latitude, low demands (%)	29.2	34.6	25.7	29.4	26.8
High latitude, low demands (%)	23.6	22.2	24.9	22.0	25.5
Low latitude, high demands (%)	22.8	20.2	24.7	21.4	25.3
High latitude, high demands (%)	24.4	23.0	24.7	27.2	22.5
Occupation, % (N=4469)					
Managerial/professional (%)	25.9	36.0	13.5	37.8	15.3
Technical/sales/support (%)	39.6	29.0	25.9	43.6	55.9
Service (%)	16.4	11.8	23.3	11.9	19.4
Farming/forestry/fishing (%)	0.7	1.5	0.6	0.8	0.1
Precision/craft/repair (%)	6.7	11.5	12.6	2.5	1.9
Operators/fabricators/laborers (%)	10.7	10.3	24.1	3.5	7.5
Year 10 (1995/1996)					
N	3942	950	805	1070	1117
Mean age, y	35.0 (0.06)	35.5 (0.11)	34.3 (0.13)	35.6 (0.10)	34.5 (0.12)
Job characteristics (N=3865)					
Median decision latitude score	37	39	36	38	36
Median psychological demands score	31	32	30	32	31
Low latitude, low demands (%)	31.2	32.5	33.0	30.0	30.0
High latitude, low demands (%)	23.9	23.7	25.2	21.3	25.7
Low latitude, high demands (%)	21.1	19.0	21.3	21.1	22.8
High latitude, high demands (%)	23.8	24.8	20.5	27.5	21.5
Occupation, % (N=3723)					
Managerial/professional (%)	36.5	47.5	21.2	52.7	22.5

Characteristics	Total	White men	Black men	White women	Black women
Technical/sales/support (%)	33.0	26.0	22.1	31.8	48.6
Service (%)	12.9	7.0	18.5	8.1	18.6
Farming/forestry/fishing (%)	1.2	2.0	1.6	0.9	0.4
Precision/craft/repair (%)	6.1	10.7	11.1	2.4	1.8
Operators/fabricators/laborers (%)	10.3	6.8	25.5	4.1	8.1

Table 2

Unadjusted Prevalence of Coronary Artery Calcium by Job Characteristics, Occupational Category, Race, and Sex: the CARDIA Study, 1987—2006

	% Positive CAC (2000/2001 or 2005/2006)				
	Total	**White men**	**Black men**	**White women**	**Black women**
Year 2 (1987/1988)					
Job characteristics (N=3251)					
Low latitude, low demands	17.7	30.5	19.3	9.8	10.6
High latitude, low demands	17.9	32.1	26.1	11.3	7.2
Low latitude, high demands	16.2	28.9	20.3	8.4	10.7
High latitude, high demands	18.1	35.0	19.5	11.2	8.7
Occupation (N=3401)					
Managerial/ Professional	17.9	33.0	17.8	8.9	7.0
Technical/Sales/Support	15.2	29.5	23.9	10.4	9.3
Service	16.5	28.4	16.1	12.3	12.3
Farming/Forestry/Fishing	24.0	—	—	—	—
Precision/ Craft/ Repair	24.9	35.9	19.8	18.5	—
Operators/ Fabricators/Laborers	26.0	32.5	29.0	0	21.2
Year 10 (1995/1996)					
Job characteristics (N=3282)					
Low latitude, low demands	19.1	29.9	26.5	10.7	10.9
High latitude, low demands	17.6	32.4	18.9	9.5	10.6
Low latitude, high demands	16.4	27.0	17.1	11.2	12.3
High latitude, high demands	17.4	32.2	22.3	10.0	8.1
Occupation (N=3169)					
Managerial/ Professional	15.4	28.9	15.3	8.9	3.6
Technical/Sales/Support	15.0	29.5	17.5	10.7	9.1
Service	20.7	30.5	22.7	19.7	15.7
Farming/Forestry/Fishing	37.8	—	—	—	—
Precision/ Craft/ Repair	30.5	39.8	23.7	17.4	—
Operators/ Fabricators/Laborers	24.7	33.3	26.4	8.8	22.1

Data not shown if sample size <20.

Table 3

Adjusted Odds Ratios for Coronary Artery Calcium in 2000/2001 or 2005/2006 by Job Characteristics and Occupational Category in 1987/1988 and 1995/1996: the CARDIA Study, 1987–2006

	Odds of positive CAC (2000/2001 or 2005/2006)	
	Adjusted odds ratio	95% CI
Year 2 (1987/1988)		
Job characteristics		
Decision latitude (continuous variable)	1.01	0.99—1.03
Psychological job demands (continuous variable)	1.00	0.98—1.02
Ratio of demands/latitude (continuous variable)	0.93	0.65—1.33
Low versus high latitude	0.85	0.69—1.04
Low versus high demands	0.98	0.80—1.19
Other versus high job strain	1.09	0.86—1.39
Low latitude, low demands	0.84	0.64—1.11
High latitude, low demands	1.0	Referent
Low latitude, high demands	0.85	0.64—1.14
High latitude, high demands	1.01	0.77—1.34
Occupation		
Managerial/professional	0.64	0.44—0.94
Technical/sales/support	0.68	0.49—0.96
Service	0.61	0.42—0.90
Precision/craft/repair	0.66	0.42—1.03
Operators/fabricators/laborers	1.0	Referent
Year 10 (1995/1996)		
Job characteristics		
Decision latitude (continuous variable)	1.01	1.00—1.03
Psychological job demands (continuous variable)	1.01	0.99—1.02
Ratio of demands/latitude (continuous variable)	0.86	0.57—1.29
Low versus high latitude	0.93	0.76—1.15
Low versus high demands	0.93	0.76—1.14
Other versus high job strain	1.01	0.79—1.29
Low latitude, low demands	0.98	0.75—1.29
High latitude, low demands	1.0	Referent
Low latitude, high demands	1.01	0.75—1.36
High latitude, high demands	1.11	0.83—1.47
Occupation		
Managerial/professional	0.59	0.40—0.87
Technical/sales/support	0.68	0.48—0.97
Service	0.92	0.62—1.36
Precision/craft/repair	1.02	0.66—1.60

	Odds of positive CAC (2000/2001 or 2005/2006)	
	Adjusted odds ratio	**95% CI**
Operators/fabricators/laborers	1.0	Referent

CAC, coronary artery calcium; CI, confidence interval

The table presents results of separate multivariate logistic regression models (years 2 and 10) for decision latitude, psychological demands, and job characteristics entered as either continuous or categorical variables. The results for occupation are from the same regression model with the 4-level latitude/demand variable entered categorically. Models also adjusted for respondents' race, sex, age, education, and site of study participation. Persons in forestry, farming, and fishing occupations were excluded from analyses because of small sample sizes.

Table 4

Association Between Changes in Job Characteristic and Job Strain Status from year 2 (1987/1988) to year 10 (1995/1996) and the Probability of CAC at Year 15 (2000/2001) or year 20 (2005/2006): the CARDIA study, 1987–2006

		Positive CAC at year 15 or year 20		
Year 2	**Year 10**	**% positive CAC, unadjusted**	**Adjusted odds ratio**	**95% CI**
Decision latitude				
Low	Low	16.5	0.80	0.61, 1.06
High	Low	19.8	1.29	0.95, 1.77
Low	High	18.2	1.14	0.83, 1.56
High	High	17.5	1.00	Referent
Psychological Demands				
Low	Low	18.8	1.0	Referent
High	Low	17.0	0.98	0.73, 1.31
Low	High	16.0	0.97	0.71, 1.31
High	High	17.8	1.10	0.84, 1.43
Job Strain				
Low	Low	18.2	1.0	Referent
High	Low	17.4	1.01	0.75, 1.38
Low	High	18.2	1.17	0.86, 1.61
High	High	13.0	0.75	0.49, 1.15

CAC, coronary artery calcium; CI, confidence interval

From separate multivariate logistic regression models adjusting for occupation, race, sex, age, site of study participation, and education. Persons in forestry, farming and fishing occupations were excluded from analyses because of small sample sizes.